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TECHNICAL REPORT BRL-TR-2992

BRL

IMPROVED ACCURACY AND COLLIMATION PROCEDURES OF THE M-26/27 MUZZLE BORESIGHT DEVICE

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MAY 1989

U.S. ARMY LABORATORY COMMAND

BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

During normal use the M-26/27 muzzle boresight device is a very accurate device for boresighting tank cannons. This report proposes technical improvements to the tool used for the collimation of the M-26/27 muzzle boresight device (MBD). In addition, this report makes recommendations to improve present allowable tolerances in these MBDs and suggests a field expedient method of correcting MBDs which exceed tolerances under field conditions.

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SFC James E. Dale of the United States Army Armor School, Weapons Department for technical assistance in formalizing the procedures for collimation of the muzzle boresight device.

The metal workers of the US Army Ballistic Research Laboratory, Experimental Fabrication Division for procuring the necessary stock and fabrication of the test tools.

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AN INVESTIGATION INTO THE ACCURACY AND COLLIMATION PROCEDURES OF THE M-26/27 MUZZLE BORESIGHT DEVICE

I. THE PROBLEM AND ITS BACKGROUND

The accuracy of tank cannons has long been considered extremely important to a crew's survivability on the modern battlefield. One of the integral components of a crew's tank gun accuracy is their ability to accurately align the cannon's center of bore with the optics of the fire control system (boresight).

The United States Army has two doctrinal methods of boresighting tank cannons. The primary method requires the use of the M-26/27 Muzzle Boresight Device (MBD). The alternate is known as the "two-point method" which requires thread, tape, and a pair of binoculars. The two-point method is used only when a MBD is not available or the MBD can not be used because of excessive gun tube wear.

In November 1986, the Science Advisor to the Commander in Chief, US Army Europe (USAREUR) and the 7th Army, requested the US Army Ballistic Research Laboratory (BRL), Aberdeen Proving Ground (APG), MD, to present possible enhancements to tank gun accuracy available to support the Canadian Army Trophy (CAT) Teams of the US Army. During the presentations in Germany to the CAT 87 teams it was brought to BRL's attention by SFC Edward Braese, Master Gunner for Company A, 2nd Battalion, 64th Armor, that there was a need to improve the current tools required to collimate the M26/27 MBD and that the allowable tolerance for the MBD excessive. After discussion with the Science Advisor, it was agreed that the BRL would look for a solution to the problem.

The MBD can be collimated to an error of 0.15 mil, but a problem arises on how to achieve this level of accuracy under field conditions. The Department of the Army (DA) Field Manual 17-12-1 and DA Field Circular 17-12-1A1 allow the device to have 1.0 mil of error in elevation and 0.50 mil of error in deflection. According to the MBD operator's manual (TM 9-4933-249-24&P) as well as the M1 and M1A1 Abrams operator's manual (TM9-2350-255-10 and TM 9-3908-4312-10) for the tank, there is no allowance for any error. Both of the above technical manuals simply state that upon rotating the MBD 180 degrees the aiming dot must remain on the same aiming point. If not, then the MBD is to be turned in to organizational maintenance. The organizational maintenance manual (TM 9-4933-249-24&P) states that there can be up to 1.0 mil of tolerance in both elevation and deflection.

Under current maintenance repair procedures, the device must be evacuated through direct support maintenance to general support maintenance for collimation and alignment if it exceeds established tolerances. The ensuing delay is extremely time consuming and can cost training time. Even after repair/realignment, there is a possibility that the M-26/27 could return with a large amount of error just under the tolerance windows because of the tools used to adjust the aiming dot of the MBD.

The tools required for the actual adjustment of the optical wedge in the MBD require improvement to consistently obtain the 0.15 mil accuracy. The actual tools required for alignment are a collar/spanner wrench and a 5/32 hex wrench (Figure 1). The MBD is designed

with the retainer plug concentric about the adjusting screws (Figure 2) used to adjust the optical wedge of the MBD (Figure 3). Since the adjusting screws are not held in position while tightening the retainer plugs, the adjusting screws are able to move, and error is induced. Given the proper tools this procedure can be done more efficiently and expeditiously.

II. OBJECTIVE

The objectives of this effort were first, to improve the tools necessary for collimation of the M-26/27 MBD; second, to demonstrate to the user that the amount of allowable error in boresight devices was excessive and suggest recommendations for improvement; and last, to formalize and submit for approval a field expedient method of collimating MBDs.

III. DESIGN AND MANUFACTURE OF THE IMPROVED TOOLS

After a careful look at the tools in use, it was determined that the current tools could be slightly modified to provide the desired results. The modification required drilling a hole 13/64 inch in diameter through the collar/spanner wrench and the manufacturing of a handle type assembly with a 5/32 inch hex wrench end attached to it. Figure 4 shows the engineering drawings that were prepared.[1] The results of this effort provided a pair of tools that could achieve the maximum acceptable error, 0.15 mil, when collimating the MBD.

IV. FIELD EXPEDIENT PROCEDURES FOR COLLIMATION/ALIGNMENT OF THE M-26/27 MUZZLE BORESIGHT DEVICE

The U.S. Army's goal is to issue a MBD per tank in the inventory. Most USAREUR units have achieved the Army's goal of one MBD per tank. It became clear that a field expedient method for collimation and alignment of the MBD was being used by US troops in Germany, although the procedure had never been formalized. Since the method is very useful, we have developed a description of the procedure and coordinated with the proponent, the Weapons Department, US Army Armor Center and School. This description is included at Appendix A.[2]

The procedure enables a tank crew to fine tune a MBD in an existing tube without sending the device to maintenance for repair. The process of MBD collimation at the operator level was demonstrated very successfully during CAT 87.

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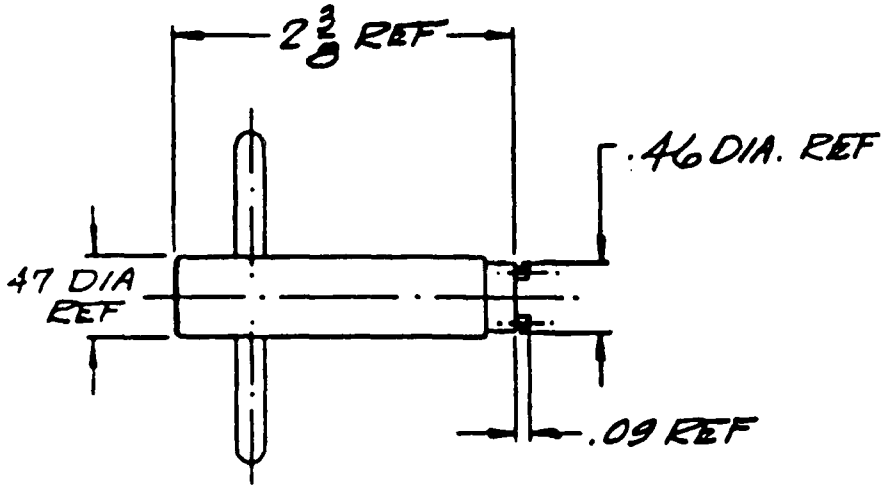
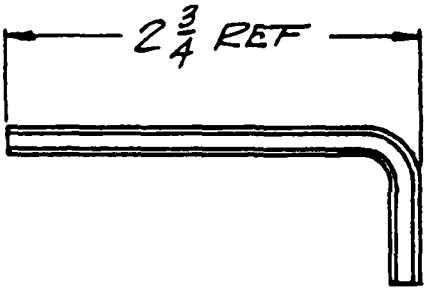
[1] *Rough sketches were prepared by MSG Michael R. Womer Sr, US Army Ballistic Research Laboratory, and engineering drawings were prepared by Mr. Lawson F. Narvell, Human Engineering Laboratory.*

[2] *Point of contact for boresighting and muzzle boresighting device was SFC James E. Dale, US Army Armor School, Fort Knox, Ky.*

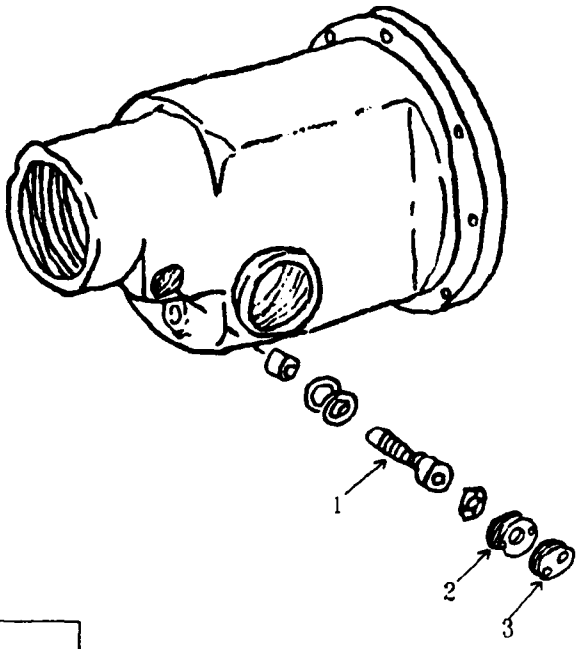


Standard Locking Tool



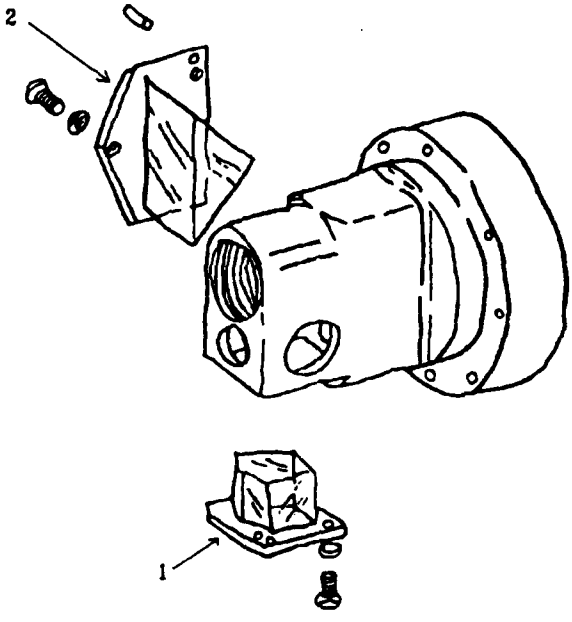
Standard 5/32 Allen Wrench

Figure 1. Engineering Drawings of Original MBD Tools



Item	Description
1	Adjusting Screw
2	Plug, Retaining
3	Plug Sealing

Figure 2. Retainer/Sealer Plugs/Adjusting Screw and Associated Parts



Item	Description
1	Prism, Optical Wedge Reticle
2	Prism, Optical Instrument

Figure 3. Optical Unit and Related Parts

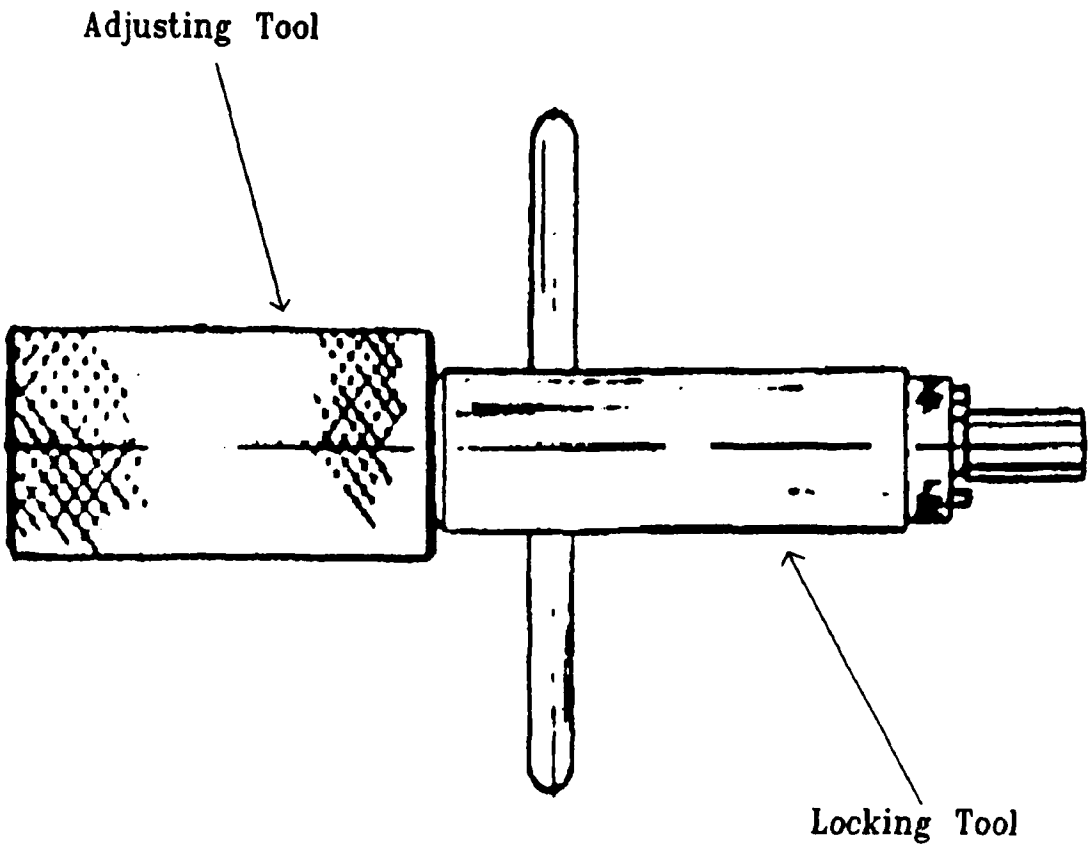
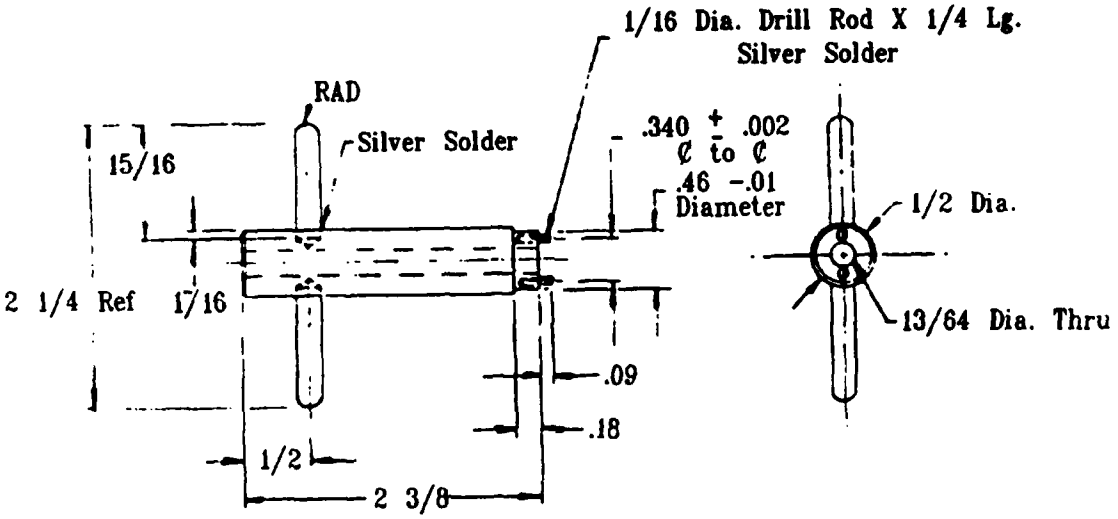


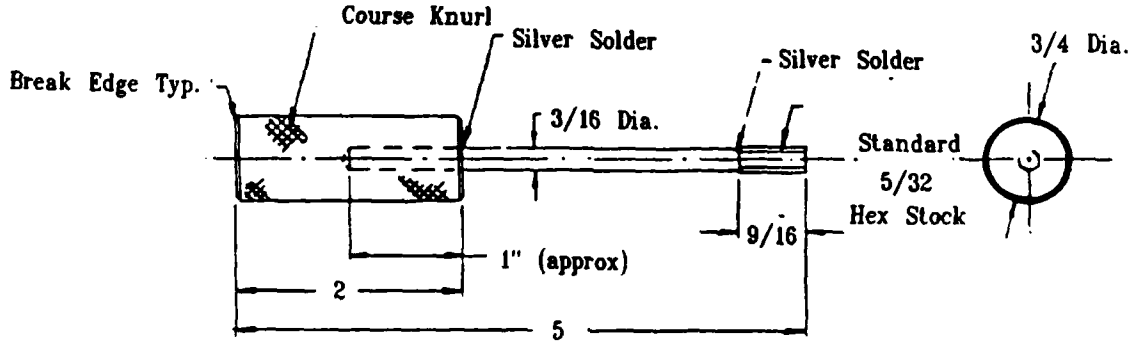
Figure 4. Engineering Drawings of Improved MBD Tools



Locking Tool

Matl. Steel FS-4130 or 4140
Provide Carburized Finish

Figure 4a. Engineering Drawings of Improved MBD Tools



Adjusting Tool
Matl. Steel FS-4130 or 4140
Provide Carburized Finish

Figure 4b. Engineering Drawings of Improved MBD Tools

V. EFFECTS OF BORESIGHT DEVICE ERROR ON TANK GUN ACCURACY

It is essential that the allowable tolerance in MBDs be reduced to more acceptable levels. Currently, the amount of tolerance is up to 1.0 mil in elevation and 0.50 mil in deflection. These values are in accordance with DA Field Manual 17-12-1 and DA Field Circular 17-12-1A1. There are other publications which allow for even greater tolerances; however, the previously stated publications are the primary references used by Armor units in the Army today.

During the actual boresight procedure one must rotate the MBD 180 degrees to determine its accuracy in locating the exact center of bore of the gun tube. If after rotating the MBD 180 degrees, its aiming dot does not exactly realign with the original aiming point, the difference must be divided by two to determine the mean boresight readings (actual center of bore). The greater the difference between the first boresight reading and the second, the greater the opportunity for crew error in applying a correct boresight to their fire control system. The ability of a crew to accurately collimate a M26/27 MBD to their specific tank, would enhance the crew's confidence that their tank will be able to hit targets through a more accurately boresighted fire control system.

If the maximum errors stated above actually existed, then one would induce 1/2 of those errors into the fire control system by splitting the differences as directed in the boresighting procedures. This error could be eliminated by performing an independent zero of the gun. However, it is policy that individual zero exercises are not conducted. Instead, the gun is fired from the boresight with a common computer correction factor for a specific type of ammunition. This procedure does not allow for an error in the strike of the round from the aimpoint as a result of different gun tube characteristics or fire control errors induced as a result of a faulty MBD.

Assuming all other error sources were corrected, the effects of a faulty MBD can be examined. The results of a .5 mil (elevation) by .25 mil (deflection) MBD error induced during boresighting procedures on M490 TP-T ammunition are depicted in Figures 5-7. The range is varied from 900 meters to 1500 meters to demonstrate the increasing effect at the greater ranges. The same conditions and ranges were examined for M724 TPDS-T ammunition (Figures 8-10). The plots clearly show the M1 fire control system cannot hit its desired aim point because of the error induced by the MBD. When the MBD error is coupled with all other error sources, the tank fire control system Ph is lowered.

VI. OBSERVATIONS AND CONCLUSIONS

This effort has been a quick reaction to provide the soldiers in the field with an alternative to accurately align MBDs when boresighting a tank cannon. If a MBD is out of tolerance, the Ph of the tank main gun ammunition is greatly reduced. The purpose of the boresighting is to accurately calibrate a main gun.

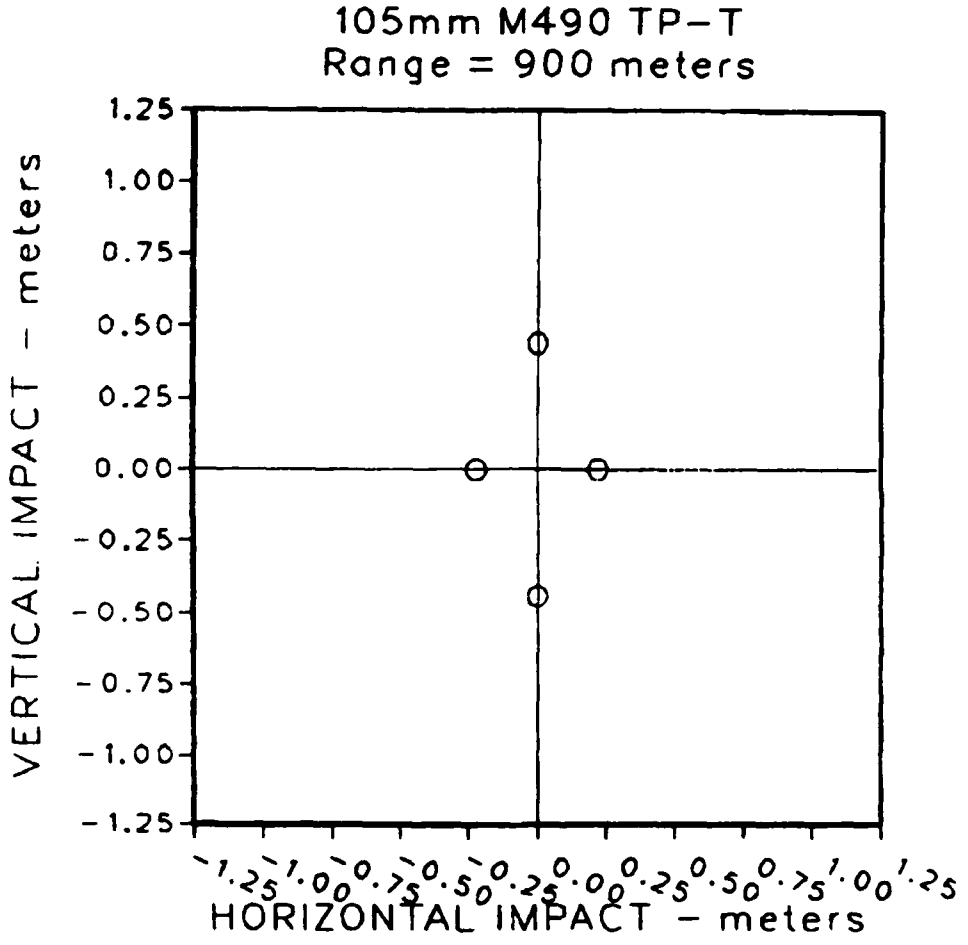


Figure 5. Predicted Impact at 900m; M490 TP-T.

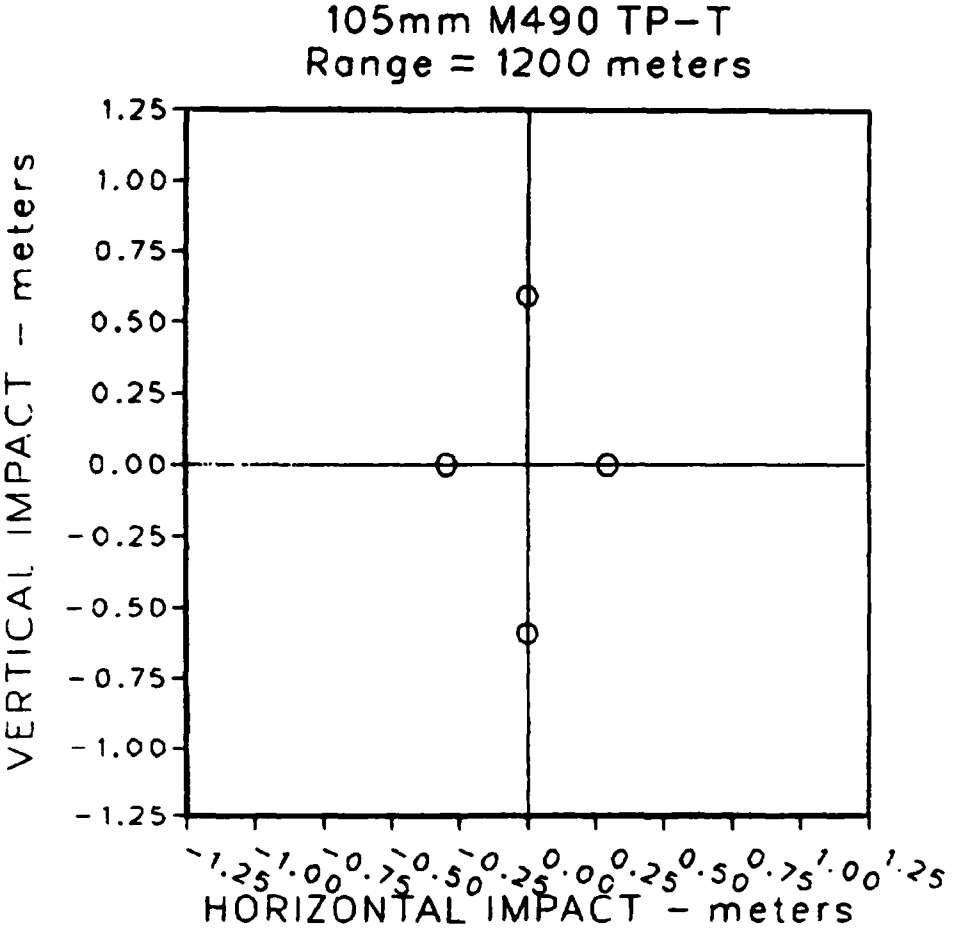


Figure 6. Predicted Impact at 1200m: M490 TP-T.

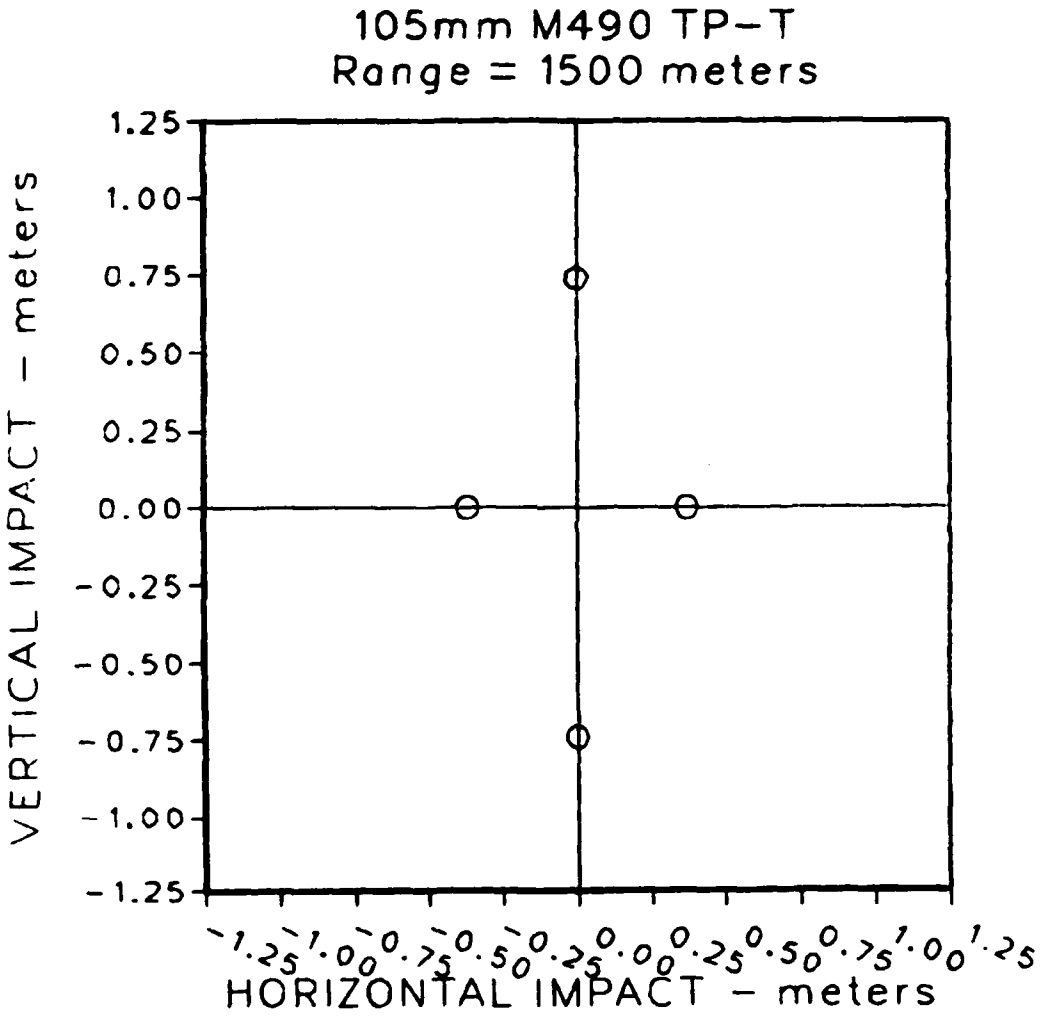


Figure 7. Predicted Impact at 1500m; M490 TP-T.

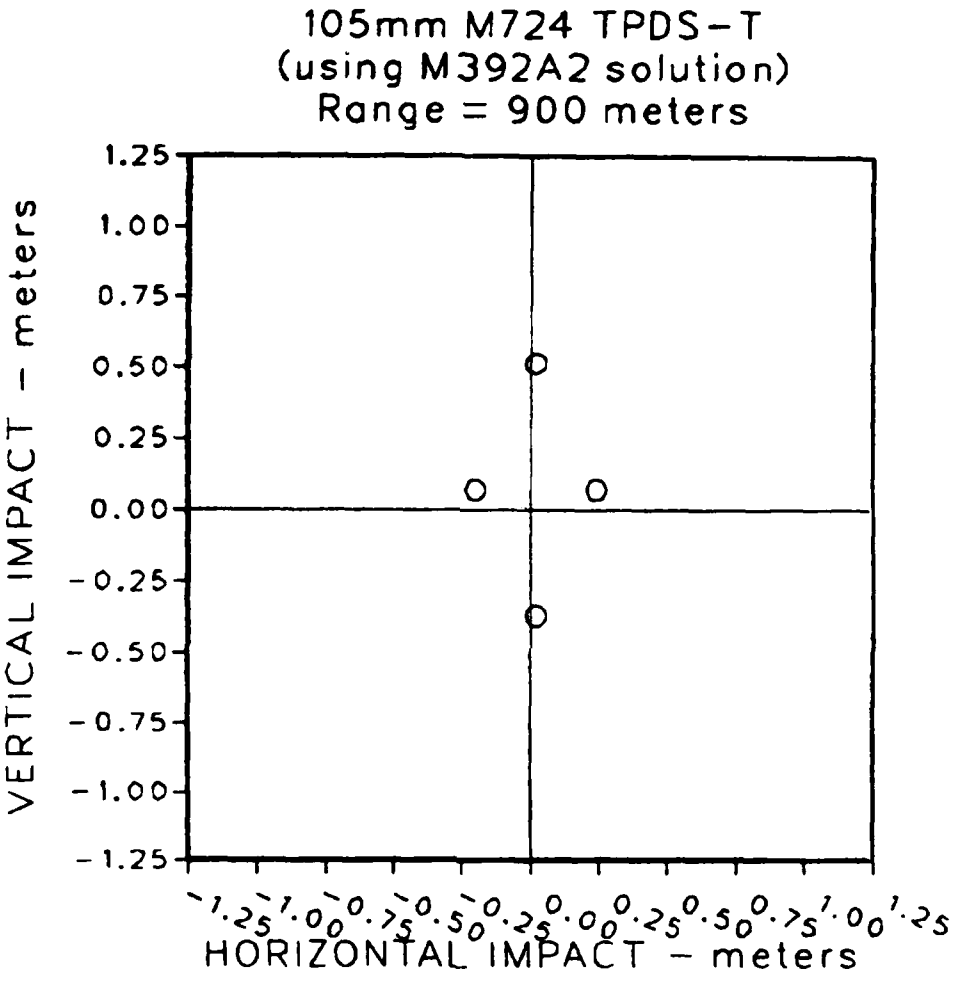


Figure 8. Predicted Impact at 900m; M724 TPDS-T.

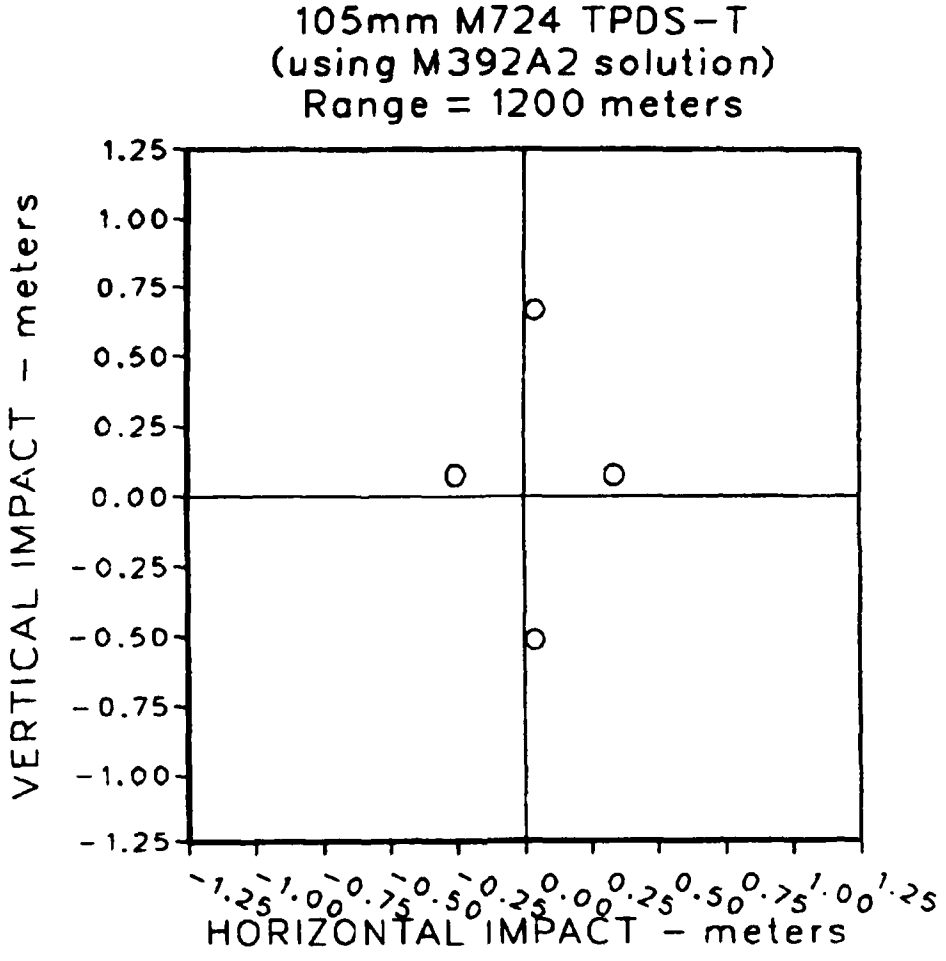


Figure 9. Predicted Impact at 1200m; M724 TPDS-T.

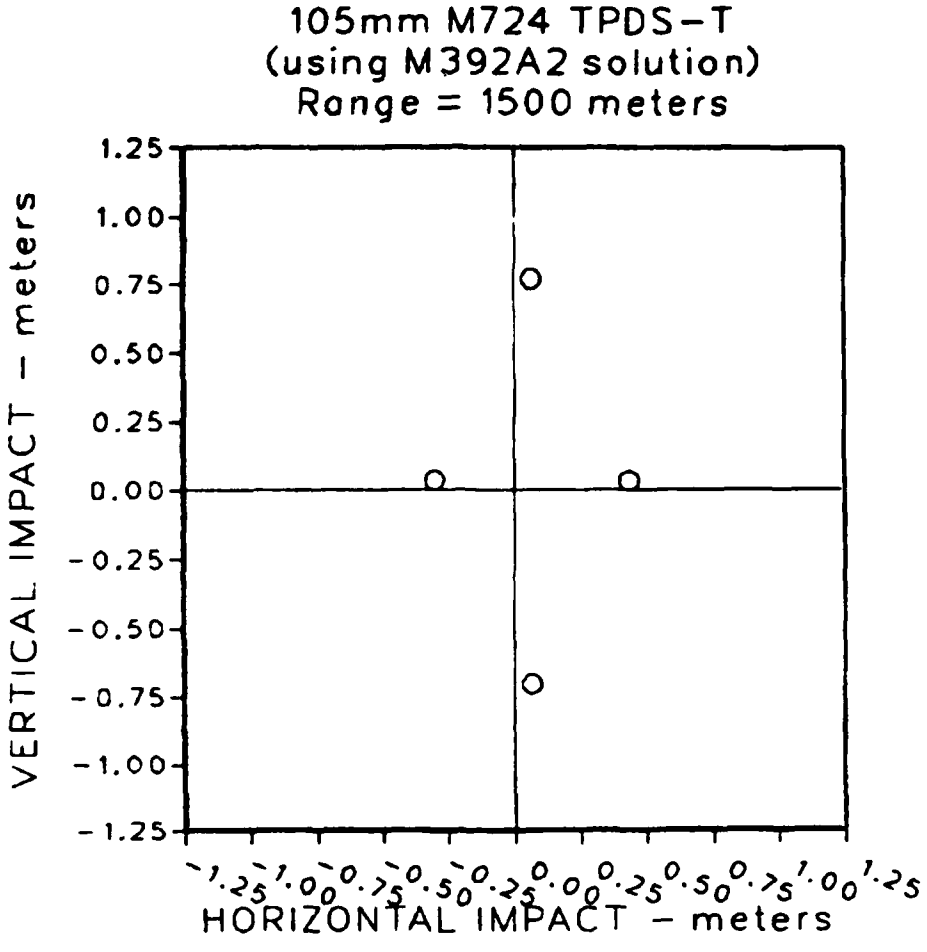


Figure 10. Predicted Impact at 1500m; M724 TPDS-T.

VII. RECOMMENDATIONS

The authors make the following recommendations:

- That the Army review and accept the new configuration of these tools.

- That the Army review the field expedient procedures for alignment/collimation of the M-26/27 muzzle boresight and adopt a policy for its use under special conditions.

- That the Army review the amount of acceptable tolerance in the M-26/27 MBD and reduce those tolerances accordingly.

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FM17-12-1, Tank Combat Tables M-1, 3 Nov 86.
FM17-12-1A1, Tank Combat Tables M-1A1, 30 Apr 86.
TM9-4933-249-24&P, M-26 Boresight w/case, 9 Jul 85.
TM9-3908-4312-10, M-26 Muzzle Boresight, 13 Dec 82.
TM9-2350-264-10-2, Tank Combat FT 120mm M1A1, 30 Dec 85.
TM9-2350-255-10-2, Tank Combat FT 105mm M1, 30 Nov 81.

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APPENDIX A

THE FIELD EXPEDIENT METHOD OF ALIGNMENT/COLLIMATION OF THE M-26/27 MUZZLE BORESIGHT DEVICE ON THE M1/M1A1 MAIN BATTLE TANK

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SFC JAMES E. DALE
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APPENDIX A

THE FIELD EXPEDIENT METHOD OF ALIGNMENT/COLLIMATION OF THE M-26/27 MUZZLE BORESIGHT DEVICE ON THE M1/M1A1 MAIN BATTLE TANK

1. Purpose: To fine tune the MBD to a specific gun tube or align the device without the support of intermediate general support maintenance.

2. Procedure:

a. Position the vehicle on level ground.

b. Prepare the gunners station for operation IAW TM9-2350-264-10-2 (see page 2-194 through 2-222).

c. Select a boresight target as close to 1200 meters away as possible. Target should be placed so the main gun is over the front of the tank when it is aligned with target.

d. Make sure that gunner's hydraulic pressure gage shows 1500 to 1700 psi.

e. Set GUN SELECT switch to MAIN.

f. Set MAGNIFICATION lever to 10X.

g. Make sure FILTER/CLEAR/SHUTTER switch is set to CLEAR.

h. Make sure DAY ballistic door is open.

i. Set FIRE CONTROL MODE switch to EMERGENCY.

j. Using the gunner's power control handles, look in gunner's primary sight (GPS) eyepiece, lay reticle aiming circle on center of target, and lase to the target.

k. Set FIRE CONTROL MODE switch to MANUAL.

l. Remove muzzle plug from main gun.

m. Remove protective cover from MBD. (Note: Two individuals required).

n. Remove the two sealing plugs in order to expose the retaining plugs and the adjusting shoulder screws.

o. Insert the MBD into the end of the gun tube. The locating pad assembly should be at the 12 o'clock position.

p. With the master gunner looking through the MBD and giving directions, the gunner will use manual controls to lay the aimpoint of the MBD to the upper left hand corner of the boresight target. The standard US Army "G" Pattern (method used to manipulate gun controls) will be used. This becomes the starting point.

q. Rotate the MBD to the 6 o'clock position. If the aiming dot has moved away more than 1/3 the width of the dot, the device is out of alignment.

(Note: Rotating the MBD while still in the main gun may result in damage to the device and or the main gun. Remove the MBD from the gun barrel for rotating.)

r. To adjust, slightly loosen the retainer plugs that secure the optical wedge shoulder screws.

s. Utilizing the 5/32 hex wrench, adjust the aiming dot 1/2 the distance between the aiming points in step p and q above by turning the optical wedge adjusting screws.

(Note: The reticle in the MBD does not move left to right or up and down as normal sight reticles, but in a curve as shown in Figure A-1. It should also be noted that the adjusting screws do not have a mechanical stop.)

t. Repeat steps p through s as many times as necessary in order to align the device to within .15 mil.

(Note: If after several attempts to align the device the aiming dot is still off, gun tube wear (muzzle bell) may be present.

u. After alignment is complete use the improved tool set to hold the adjusting screw in place and tighten the retainer plugs. Make sure that the aiming dot does not move during this step.

v. Replace the sealing plug.

w. Replace the protective cover.

x. The device is now aligned for the specific gun in which it was adjusted. If used in another gun, check the alignment and adjust as needed.

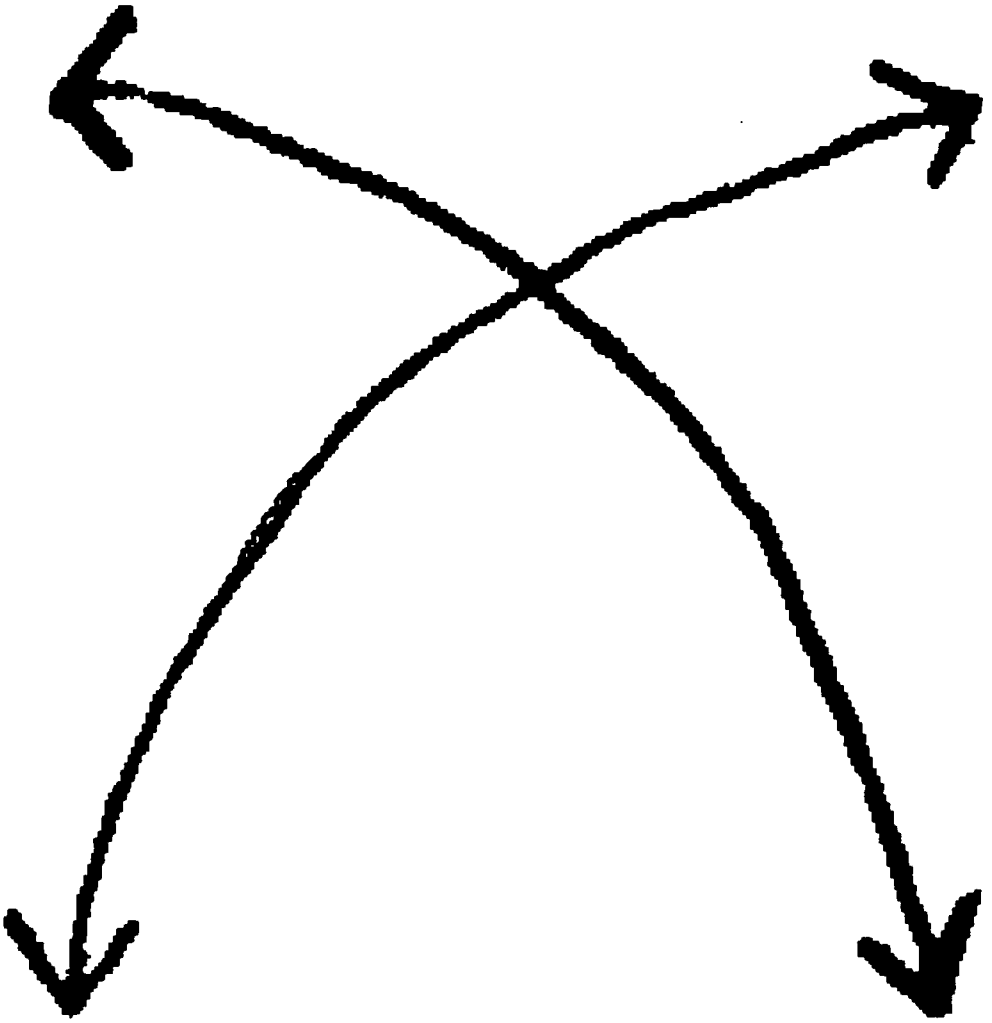

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Figure A-1. Reticle Movement in MBD.

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